EASTERN WHITE PINE IN EASTERN NEBRASKA: A Provenance Study of Southern Appalachian Origins

John A. Sprackling and Ralph A. Read

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Keywords: *Pinus strobus*, provenances, growth, tree form, needles, ornamentals, Christmas trees.

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A Provenance Study of Southern Appalachian Origins

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Preface

This provenance study is one of a dozen experimental plantations of various tree species established on the Horning State Farm near Plattsmouth, Nebraska, which is administered by the Department of Forestry of the University of Nebraska. The USDA Forest Service, through its Rocky Mountain Forest and Range Experiment Station Research Work Unit at Lincoln, cooperates with the Nebraska Agricultural Experiment Station in research conducted on this experimental area.

The specific purpose of this work is to find and develop better adapted trees for use in all kinds of plantings, environmental and commercial, throughout Nebraska and the Central Plains. Such provenance studies of different species provide plants of known origin for evaluation of adaptability, and genetic variation, and for selection, propagation, and breeding for resistance to disease and insect pests. Studies have been reported in publications listed below.

The diversity of tree planting materials under study at this and many other locations in the Plains was made possible through cooperation in a Regional Tree Improvement Project (NC-99, formerly NC-51) of the North Central States Agricultural Experiment Stations.

Credits are due Jonathan W. Wright, Professor of Forestry, Michigan State University, for initiating the Regional study and providing the planting stock, and to Walter T. Bagley, Associate Professor of Forestry, University of Nebraska, for cooperation in planting and maintenance of the plantations.

Published Reports on Provenance Studies

1971. Scots pine in eastern Nebraska: A provenance study. USDA For. Serv. Res. Pap. RM-78, 13 p. by Ralph A. Read.

1975. Jack pine provenance study in eastern Nebraska. USDA For. Serv. Res. Pap. RM-143, 8 p. by John Sprackling and Ralph A. Read.

1975. Red pine provenance study in eastern Nebraska. USDA For. Serv. Res. Pap. RM-144, 7 p. by John A. Sprackling and Ralph A. Read.

1976. Douglas-fir in eastern Nebraska: A provenance study. USDA For. Serv. Res. Pap. RM-178, 10 p. by Ralph A. Read and John A. Sprackling.

1976. Eastern white pine in eastern Nebraska: A provenance study of southern Appalachian origins. USDA For. Serv. Res. Pap. RM-179, 8 p. by John A. Sprackling and Ralph A. Read.

1976. Austrian (European black) pine in eastern Nebraska: A provenance study. USDA For. Serv. Res. Pap. RM-180, 8 p. by Ralph A. Read.

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From colonial days to the turn of the twentieth century, eastern white pine (*Pinus strobus* L.) was prized by lumbermen above all other trees. Its natural range extends from Newfoundland to Minnesota, and south throughout the Appalachian Mountains to Georgia (fig. 1). Good white pine is now in short supply, and the species is no longer utilized for lumber to the extent that it once was. But in the eyes of arborists, nurserymen, and landscape architects, eastern white pine rates high for arboreal elegance and beauty.

This study was initiated as part of a continuing search for improved trees that can be successfully introduced to the relatively treeless

Figure 1.—Natural range of eastern white pine (*Pinus strobus*).

prairies of the central Great Plains. Eastern white pine has been planted in eastern Nebraska since the 1800's for ornamental purposes and to a much lesser extent for windbreaks, yet no information has been available concerning specific seed origins suited for various types of plantings. Thus, the primary goal of this provenance test was to determine which seed origins of eastern white pine from the southern Appalachians might be well adapted for windbreaks, Christmas trees, and landscaping purposes in the central Plains. Hopefully, such information will improve success of future plantings. The study was conducted as part of a cooperative Regional Tree Improvement Project (NC-99) of the North Central States Agricultural Experiment Stations.

Previous Work

Distinct geographic races have not been delineated within the range of eastern white pine, but genetic differences in growth rates, drought resistance, branching habit, and blister rust (*Cronartium ribicola* Fischer) resistance have been indicated (Fowells 1965, Wright 1970).

A rangewide provenance test involving three plantations established in Virginia, North Carolina, and Georgia revealed that trees of southern Appalachian origins surpassed all others in height growth. Trees from Maine, Minnesota, and Quebec grew slowest (Sluder and Dorman 1971). Garrett et al. (1973), after 10 years of provenance testing at 13 plantation sites throughout the northeastern United States, also concluded that trees of southern origins grew fastest. Trees from Georgia and Pennsylvania seed origins, after 7 years in two Ontario plantations, were significantly taller than plantation averages, while Iowa, Minnesota, and Quebec origins were shorter (Fowler and Heimburger 1969). Studies in Illinois and Indiana indicated that trees of Georgia, Tennessee, and North Carolina origins were consistently taller than plantation averages after 10 years, while trees from Maine, Minnesota, and Quebec were shorter than average (Funk 1971). In two Michigan plantations, the fastest growing trees were from Tennessee, Georgia, Pennsylvania, and Ontario seed origins, in that order (Wright et al. 1963). Only in Minnesota and Wisconsin tests have trees from southern Appalachian origins grown slower than trees from northern origins (King and Nienstaedt 1968).

Trees of northern origins tend to produce more lateral branches (Funk 1971), develop more late-summer shoots (Wright et al. 1963,) and produce more cones at an early age (Garrett et al. 1973) than trees from southern origins. Survival rates of trees from southern origins exceeded those of northern origins in Michigan plantations (Wright et al. 1963), but were not correlated with latitude in three southern Appalachian plantations (Sluder and Dorman 1971). Wright et al. (1963) determined that eastern white pines of southern Appalachian origins had blue-green foliage, while those from Maine and the Lake States were green with no bluish cast. Garrett et al. (1973) concluded that trees from southern Appalachian origins produced the longest needles.

Methods

Seed collections from many geographic origins throughout the southern Appalachian Mountains were obtained over a 3-year period by Jonathan W. Wright, Michigan State University. The seeds were planted in a Michigan State University nursery at East Lansing. In April 1968, 2,530 (1+0) seedlings of 135 seed lots were lifted and air freighted to the Colorado State Forest Service nursery in Fort Collins, where they were potted in 2- by 2- by 9-inch tarpaper pots. They were then trucked to Lincoln, Nebraska, and placed in a shade house.

The 1+1 transplants were field planted in April 1969, at the University of Nebraska's Horning State Farm, near Plattsmouth, Nebraska, located at 41° north latitude, 96° west longitude, and 1,100 feet (335 m) elevation. The plantation is located on a gentle north-facing slope of silt loam soil derived from loess. The growing season averages 170 days, and mean annual precipitation is 30 inches (76 cm) of which 75 percent falls during the growing season.

The trees were machine planted with tarpaper pots intact in contour rows which had been sprayed the previous fall to kill bromegrass. Plots of each geographic location were randomly arranged within seven replications. In some cases, the two-tree plots represented a composite sample from several trees collected at a location (significance of those composites is discussed in a later paragraph). In other cases, the two-tree plots were half sibs of individual parent trees. In the latter instance, all plots of the family representing a geographic location were planted adjacent in the row. The plantation contains 24 rows spaced 11 feet (3.35 m) apart, with trees 7 feet (2.44 m) apart in each row. It has been maintained annually by mowing between rows and spraying Simazine (4 pounds per acre) and Dalapon (10 pounds per acre) in a 20-inch-band (0.5 m) along both sides of each row to control weeds.

Survival counts were made in 1970, and dead trees replaced with surplus potted stock from on site and in the shade house. Heights were measured at the end of growing seasons from 1970 to

1975. Periodically, the plantation was checked for insects, diseases, and other damage. Flowering and cone production were recorded. Other measurements made in November 1974 included:

Form.—A numerical rating of each tree, ranging from 0 to 40, was based on straightness of stem, crown density, crown balance, and branch angle. Each of the four characteristics was given a numerical rating from 0 to 10; the sum of these was the form rating. Trees with acute branch angles, straight stems, and dense, balanced crowns rated highest. Crown balance is the uniformity of lateral branching on all sides of a tree. Branch angle is the angle of lateral branches relative to the main stem.

Average lengths of 1-year-old (1974) needles.—Computed from measurements of samples taken from lateral branches on the south side of each tree.

Foliage color.—Blue green, green, or yellow green.

Analysis of variance and multiple range tests were made to determine statistical significance of differences in heights and forms among the geographic locations. Correlation analyses of origin latitude, longitude, and elevation with growth characteristics were performed.

Data analyses were complicated by the fact that some seed lots were composites of several trees in a stand, while other seed lots were single-tree (half sib) progeny. Thus, comparisons among the 135 seed lots were not possible, because in many cases there were insufficient trees for reliable averages. The seed lots were therefore grouped into 21 geographic locations (table 1, fig. 2) to facilitate comparisons. These groupings are used instead of MSU origin numbers in the following discussion of results.

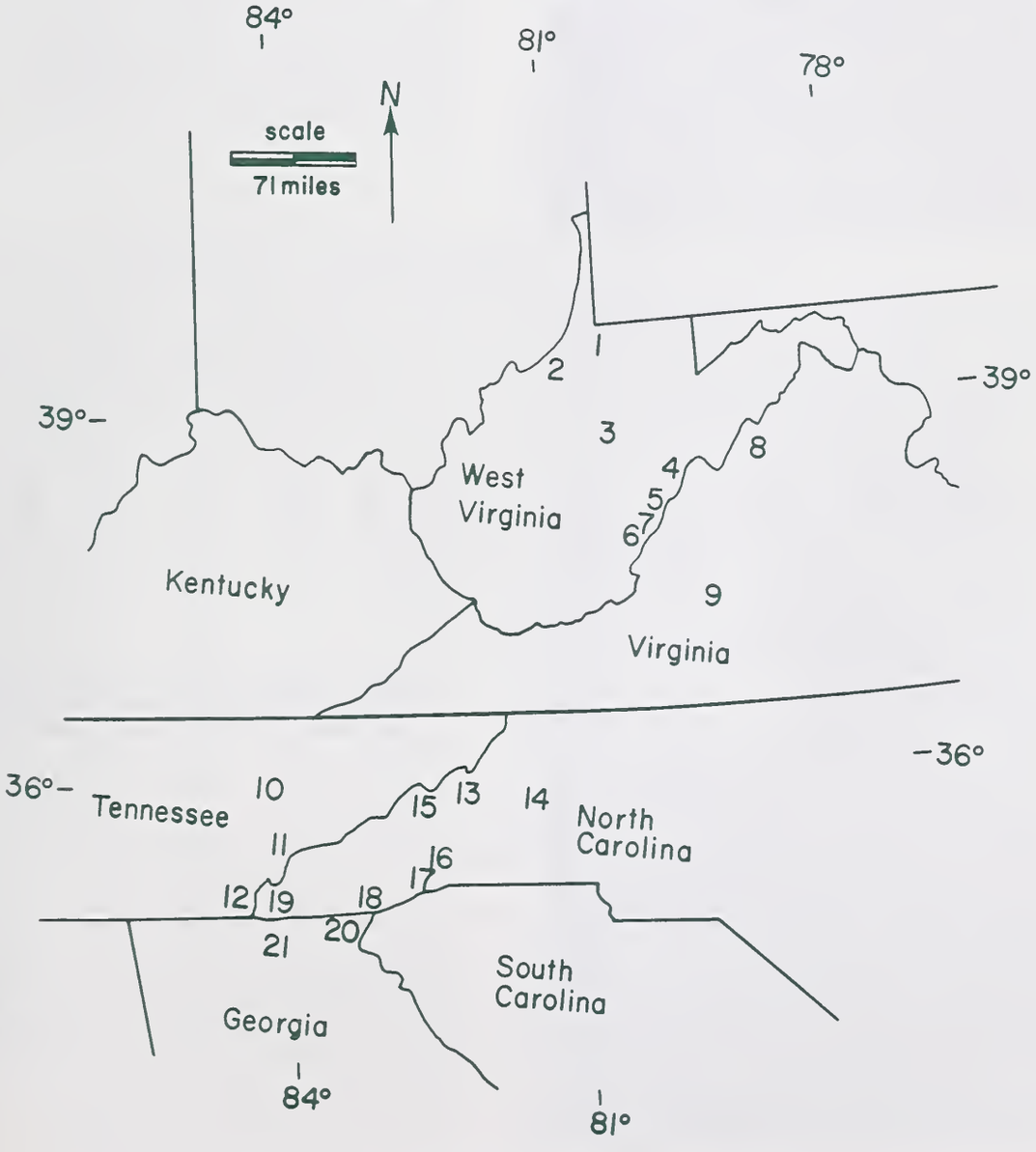

Figure 2.—Locations of eastern white pine origins tested.

Results

Seedling Survival

Plantation survival was 75 percent after two growing seasons, and declined only to 73 percent after four growing seasons. Survival rates varied widely among origins, and were not correlated with origin latitude, longitude, or elevation (table 1). Variations in success of weed and grass control during the first two growing seasons appeared to have the greatest influence on survival.

Height and Growth Rates

Height and growth rates were fairly uniform among origins (table 1). The multiple range test revealed no significant differences in heights among the tallest 12 locations, and the entire array indicated a pattern of continuous variation. Trees from Polk County, Tennessee (12) were tallest when heights were first measured in 1970, and remained so through 1975, averaging 10.9 feet at field age 7. The tallest, fastest growing individual tree was from Anderson County, Tennessee (10). This tree, 15.8 feet tall, averaged 2.8 feet height growth per year during the last 5 years, and grew 3.7 feet during the 1975 growing season (fig. 3). In contrast, trees from Cherokee County, North Carolina (19), one of the southernmost origins, were shortest. They averaged 8.2 feet, and had an average annual height growth of only 1.4 feet the last 5 years. Thus the fastest and slowest growing origins were only 25 miles apart in the Great Smoky Mountains. Growth rates of all trees have increased greatly during the last 2 years.

Form

Trees from Pocahontas County, West Virginia (5), Botetourt County, Virginia (9), and Greenbrier County, West Virginia (6) had the best form ratings with an average of 31 (table 1). Form ratings of the individual trees within origins were quite variable, but average ratings for the 21 origins varied less than did average heights. Differences in form ratings among the best 14 origins were not significant. The highest form rating in the plantation, a 39, was given to one tree from Pocahontas County, West Virginia (4) (fig. 4).

Table 1.--Eastern white pine tested in an eastern Nebraska field plantation, with seed origin, survival record, form rating,[1] needle length and height growth, 1971-75

Location in figure 2	Michigan State Univ. origin No.	State where seed originated	County where seed originated	Parent trees in collection[2]	Latitude	Longitude	Elevation		Basis: progeny trees	Survival, 2d year	Form rating	Needle length	Height growth: Mean annual 1971-75	Height growth: 7-yr total[3]	Height growth: Plantation mean
				No.	°N	°W	ft	m	No.	%		mm	ft	ft	%
1	3571-79	W VA	Wetzel	9	39.5	80.8	800	244	126	82	30	89	1.7	9.8abcd	103
2	3555,58,61,62,63	W VA	Pleasants	5	39.3	81.1	800	244	68	76	28	94	1.6	8.9 de	94
3	3580-84,86,87,89	W VA	Braxton	8	38.8	80.5	1000	305	103	77	29	91	1.5	8.4 e	88
4	3453,3590-94	W VA	Pocahontas	6	38.3	79.9	2800	853	82	80	30	87	1.6	9.1 de	96
5	3477-78	W VA	Pocahontas	?	38.0	80.0	2600	792	23	97	31	86	1.7	9.7abcd	102
6	3564-68	W VA	Greenbrier	5	38.0	80.2	2300	701	63	69	31	84	1.6	8.9 de	94
7	3461-64,69,79,80	W VA	Greenbrier	5+	38.0	80.1	2330	710	75	73	29	84	1.7	9.3 bcde	98
8	3476	VA	Rockingham	?	38.6	79.0	1500	457	12	86	30	84	1.7	9.7abcde	102
9	3470	VA	Botetourt	4	37.5	79.6	1550	472	13	71	31	82	1.7	9.3 bcde	98
10	3532-34,36-41	TENN	Anderson	9	36.0	84.2	900	274	103	68	26	94	1.9	10.5ab	111
11	3503-12	TENN	Monroe	10	35.3	84.2	1800	549	116	81	27	94	1.7	9.7abcd	102
12	3493-3502	TENN	Polk	10	35.0	84.5	1500	457	105	71	28	95	1.9	10.9a	115
13	3428-35	N C	Yancey	8	36.0	82.2	2000	610	46	75	29	94	1.8	9.9abcd	104
14	3422,83,86-89,3552	N C	Burke	11+	35.9	81.7	1470	448	69	75	30	89	1.7	9.3 bcde	98
15	3551	N C	Madison	?	35.8	82.7	2000	610	11	64	30	89	1.8	10.1abcd	106
16	3410-18,36,37	N C	Buncombe	11	35.5	82.6	2600	792	112	75	28	100	1.8	10.1abcd	106
17	3438-41,43	N C	Henderson	5	35.2	82.8	3000	914	37	77	29	95	1.8	10.3abc	108
18	3421	N C	Macon	5	35.1	83.2	4000	1219	11	57	28	87	1.7	9.4abcde	99
19	3522-31	N C	Cherokee	10	35.1	84.2	1500	457	114	66	27	84	1.4	8.2 e	86
20	3546-48	GA	Rabun	?	34.9	83.4	1800	549	35	78	28	92	1.6	9.3 cde	98
21	3513-21,42-45	GA	Fannin, Union	13+	34.7	84.2	1970	600	160	73	27	96	1.7	9.7abcd	102
							Plantation means			75	28	91	1.7	9.5	100

[1]Each tree was rated on a scale ranging from 0 to 40, based on straightness of stem, crown density, crown balance, and branch angle.
[2]? = number of parent trees not available.
[3]Duncan's range test: means with common letters are not significantly different at 5% level; means of equal value may be separated due to rounding off.

Figure 3.—Tallest tree in the eastern white pine plantation after 6 years in the field was from Anderson County, Tennessee. Photo was taken in fall 1974 when the tree was 12.1 feet tall; height growth of this tree during 1975 was 3.7 feet.

Figure 4.—Eastern white pine tree with the highest form rating (39) was from Pocahontas County, West Virginia. Crown forms such as this are especially attractive for landscaping purposes.

Other Characteristics

Needle lengths were very weakly correlated with latitude. Needles of nine northern origins averaged 88 mm in length compared to 93 mm for 12 southern origins. Trees from Buncombe County, North Carolina (16) had the longest needles, averaging 100 mm, whereas trees from Botetourt County, West Virginia (9) had the shortest needles (82 mm). Foliage color varied from blue green to green to yellow green. Foliage color was not consistent within origins.

In early spring 1972, the needles on previous years' growth turned straw color on well over 75 percent of the trees. It appeared that mortality would be severe, but close examination revealed the buds were alive. Some dieback did occur, but height growth was only slightly modified when vigorous laterals quickly assumed terminal dominance. The damage appeared to be severe desiccation of foliage by strong winds while the soil was frozen.

Heavy snow, insects, or diseases have not caused damage to date, but weather during the 2 years, 1974 and 1975, has been unusually hot and dry. New needles on many trees drooped, withered, and turned brown, especially on the south side of trees. We assume this was caused by drought and heat, because no pathogen or insect was detected; no mortality is evident.

Damage due to deer rubbing on 2.3 percent of the trees has retarded height growth, but caused no mortality. Deer showed no preference among the 21 origins; they tended to damage trees only on the periphery of the plantation.

Ovulate flowering first appeared in 1972 when trees were 6 years old. By 1974, 20 trees had cones; 15 of these were from West Virginia. The two northernmost origins, Wetzel County, West Virginia (1) and Pleasants County, West Virginia (2) had 11 flowering trees.

Discussion

Survival was excellent despite the fact that all seed origins were from milder climates and from latitudes south of the plantation site. The northern Georgia origins are growing quite well more than 6° (approximately 400 miles) north of their native habitat. In eastern Nebraska they receive half as much precipitation and have a growing season 25 days shorter than in northern Georgia. Most surprising are the low temperatures these southern origins can tolerate. The lowest temperature officially recorded over a 39-year period in northern Georgia is −9°F at Clayton (USDA 1941). Minimum temperatures recorded at Weeping Water, Nebraska, 15 miles from the test site, were lower than −9°F every year since planting (from −14°F in 1970 to −26°F in 1974), yet no cold damage had resulted.

Paleobotanists concur that, during the Pleistocene Ice Age, eastern white pine was restricted to a refugium in the Central and Southern Appalachians (Braun 1964). Following this glacial period the species migrated north to New England, Canada, and west through the Lake States. A cold-hardy gene pool, which evolved through natural selection during the glacial age, must have made possible the northward migration into colder climates, and a residual of this germ plasm in present Georgia white pines may explain why it is able to survive the colder winters of Nebraska.

Although latitude accounted for 45 percent of the variation in heights of southern Appalachian seed origins planted in Tennessee (Thor 1975), it was not correlated with heights in this study. Neither origin longitude nor location east or west of the Appalachian Range proved important. Moreover, there were no consistent height patterns among geographically related origins. For example, our tallest trees were from Polk County, Tennessee (12), only 25 miles west of Cherokee County, North Carolina (19), the origin of our shortest trees (fig. 2).

The fastest growing parent trees did not necessarily produce the fastest growing progeny (table 2). Polk County, Tennessee (12) progeny, which had the tallest average height in the plantation, came from seed of 10 parent trees in a single stand. However, the fastest growing parent tree (3501) in this stand, although averaging 2.39 feet per year for 49 years, produced progeny which rank only eighth in height among this group of 10 in the Horning plantation. In contrast, the next to slowest growing parent tree (3497) which averaged only 1.98 feet per year for 50 years, produced the tallest progeny, averaging 12.5 feet. In fact, because of the superior performance of its progeny, parent tree 3497 is strongly indicated as the best in this provenance test for producing tall offspring.

Cherokee County, North Carolina (19) progeny, which had the lowest average growth rate and height in the plantation, also came from seed of 10 parent trees in a single stand. As might be expected, the slowest growing parent tree (3530) produced the slowest growing offspring in Nebraska, averaging only 6.8 feet total height at field age 7. In contrast, the seventh fastest growing parent tree (3528) unexpectedly produced the tallest progeny of this source, averaging 9.1 feet.

It is of interest to note that Cherokee County, North Carolina (19) parent trees averaged 2.21 feet per year growth compared to 2.16 feet per year for Polk County, Tennessee (12) parent trees.

Table 2.--Height and growth rates of eastern white pine parent trees in two origin collection stands, compared to performance of their progeny in the Nebraska provenance plantation

Mich. State Univ. origin No.	Parent trees			Progeny trees		
	Total height	Age	Average annual growth	Average height	Rank	Basis: trees
	ft	*yr*	*ft*	*ft*		*No.*
POLK COUNTY, TENN (12)						
3501	117	49	2.39	10.4	8	8
3494	113	49	2.31	11.1	5	16
3499	108	47	2.30	9.3	10	8
3495	114	51	2.25	10.9	6	12
3498	108	49	2.20	12.0	2	2
3500	111	51	2.18	11.8	3	13
3493	105	51	2.06	11.2	4	12
3496	93	46	2.02	9.6	9	11
3497	99	50	1.98	12.5	1	9
3502	97	50	1.94	10.9	7	14
Mean			2.16	10.9		
CHEROKEE COUNTY, N C (19)						
3529	90	33	2.73	8.5	6	11
3523	99	39	2.54	8.7	4	12
3524	96	39	2.46	8.7	3	11
3527	90	37	2.43	8.0	7	12
3526	93	40	2.33	8.5	5	15
3525	81	38	2.13	6.8	10	11
3528	72	35	2.06	9.1	1	12
3531	87	43	2.02	8.0	8	11
3522	89	44	2.02	8.7	2	11
3530	75	42	1.42	6.8	9	8
Mean			2.21	8.2		

Thus we might expect the progenies of the two sources to be approximately equal in height growth, instead of being the shortest and tallest, respectively, of all origins tested.

The unpredictable performance of these progenies points out the difficulties encountered in evaluating selected parent trees to obtain better seed. Of course, only the maternal parents of these seed lots are known, and in addition it is possible that variations in environment (stocking levels, aspect, slope position, soil depth, nutrients, etc.) within seed collection stands have somewhat masked the genetic expression of the known parents. These uncertainties emphasize the need to minimize the unknown variations through provenance testing, particularly where trees are being introduced to sites outside their natural range.

During early establishment, plantation height growth averaged 1.1 feet per year from 1971 through 1973. Growth rates more than doubled to 2.3 feet in 1974, and 2.7 feet in 1975. Thus, this plantation is now growing faster in height than any other pine species at this location. The trees are now well established and should continue to grow rapidly for the next 10 to 20 years.

Northern origins flowered first. Thus far, no male strobili have been observed. The most prolific tree, with 9 cones at field age 6, was from Wetzel County, West Virginia (1), the northernmost origin tested. Previous white pine provenance test (Wright 1970, Garrett et al. 1973) also indicated that northern origins flower earliest and produce the most flowers.

Recommendations

The following recommendations for southern Appalachian origins of eastern white pine in Nebraska are based both on the performance of this plantation, and observations of past plantings.

The species should be planted only in the eastern part of the State, except where irrigation facilities are available. Sites should be selected for protection from wind because these trees "winter burn" easily. Eastern white pines are not recommended for general windbreak purposes. The reason is that they have a tendency to deteriorate in middle age; even when not crowded, lower branches die and crowns become very open, providing minimum protection from wind. Moreover, other conifers of greater crown density and drought resistance are available for windbreaks.

The primary uses of eastern white pine in Nebraska are therefore for ornamental plantings and Christmas trees. In ornamental plantings where rapid height growth is desired, trees from Polk County, Tennessee (12) are recommended. Average heights for this origin are based on a large number of sample trees which have been consistently tallest throughout the study. Since none of the origins tested exhibited consistently superior form or foliage color, we cannot recommend specific origins for those traits. However, growth rates of all origins tested indicate that shearing is essential to the production of quality eastern white pine Christmas trees in Nebraska.

The species might be grown for sawtimber by landowners with an eye toward long-term investments. White pine blister rust and white pine weevil, which have discouraged commercial plantings within the northern range of the species, are not found here.

The use of eastern white pine is somewhat limited in Nebraska due to its lack of drought resistance and susceptibility to winter burn on windy sites. In these latter situations, it is advisable to use southwestern white pine (*Pinus strobiformis* Engelm.), a close relative with more tolerance for drought, although slightly slower growing than eastern white pine.

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Keywords: *Pinus strobus,* provenances, growth, tree form, needles, ornamentals, Christmas trees.

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